Some Recent Research & Parting Remarks

Amarjit Soni

HET

Weak Corrections to Associated Higgs-Bottom Quark Production

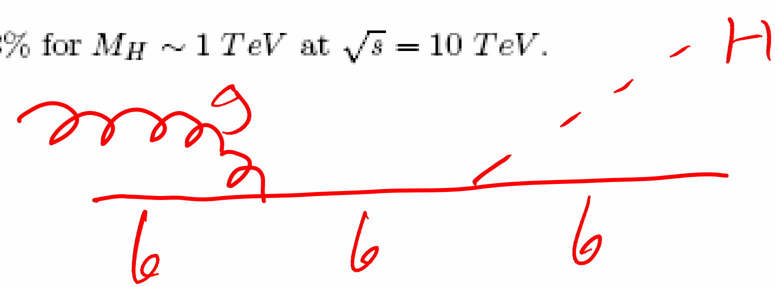
S. Dawson[a] and P. Jaiswal[a,b]

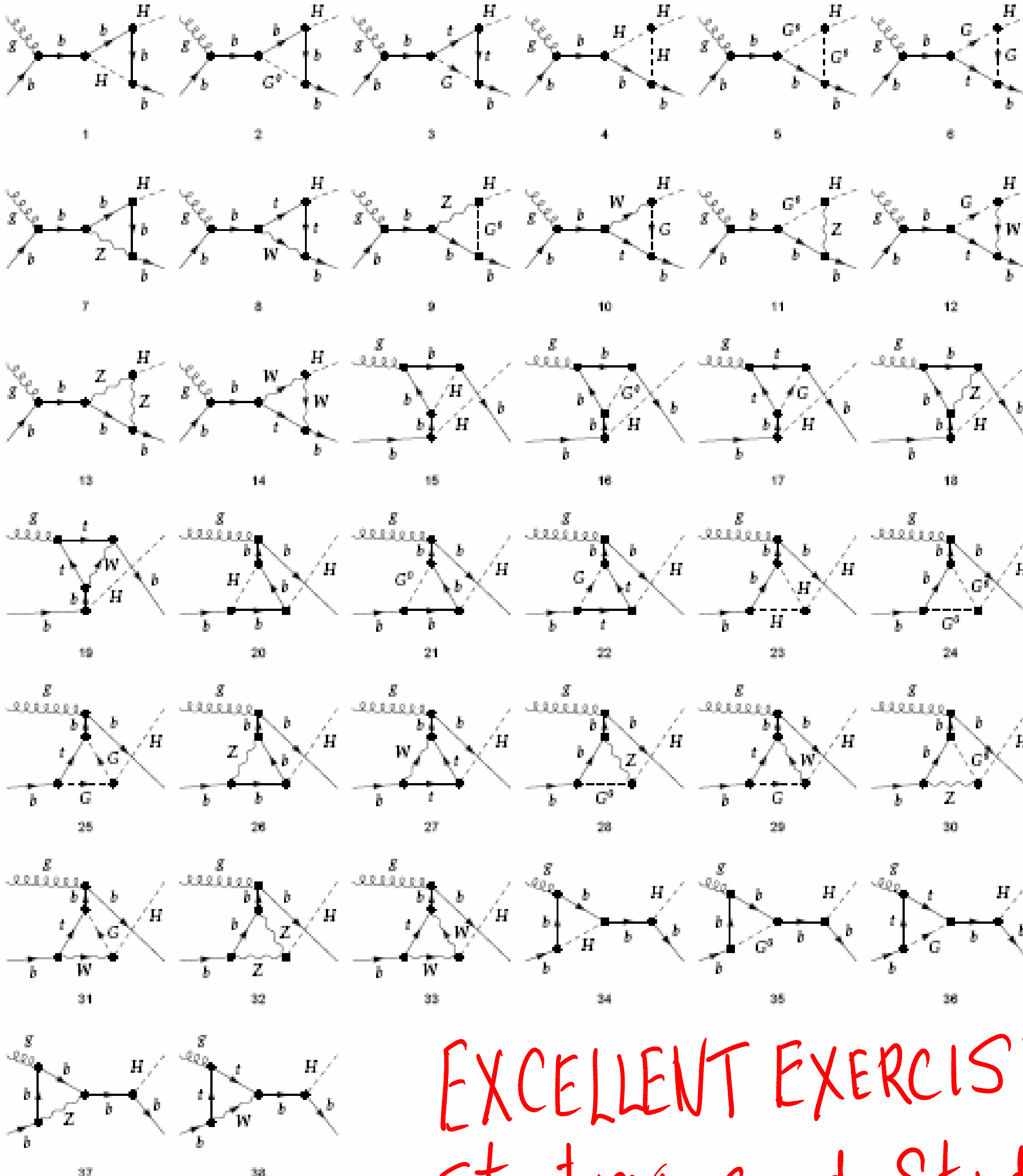
[a]Department of Physics, Brookhaven National Laboratory, Upton, NY 11973, USA

[b]Yang Institute for Theoretical Physics, Stony Brook University, Stony Brook, NY 11790, USA

Abstract

In models with an enhanced coupling of the Higgs boson to the bottom quark, the dominant production mechanism in hadronic collisions is often the partonic sub-process, $bg \to bH$. We derive the weak corrections to this process and show that they can be accurately approximated by an "Improved Born Approximation". At the Tevatron, these corrections are negligible and are dwarfed by PDF and scale uncertainties for $M_H < 200\ GeV$. At the LHC, the weak corrections are small for $M_H < 500\ GeV$. For large Higgs boson masses, the corrections become significant and are $\sim$ 18% for $M_H \sim 1\ TeV$ at $\sqrt{s} = 10\ TeV$.





+ MANY MORE

EXCELLENT EXERCISE for a starting grad student

FIG. 5: Vertex diagrams contributing to the weak corrections to $bg \to bH$.

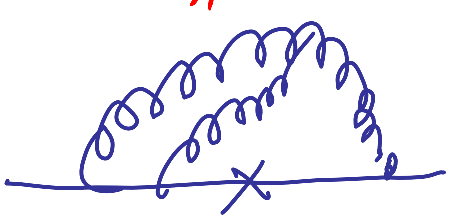
Two-loop matching factors for light quark masses and three-loop mass anomalous dimensions in the RI/SMOM schemes

SBU/HET grad student

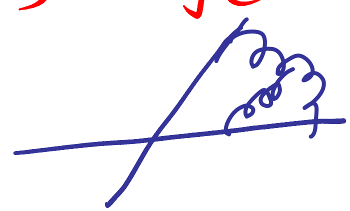
Post-doc HET

Leandro G. Almeida [a,b] and Christian Sturm [b]

EXTREMELY DIFFICULT
" IMPORTANT } FINISHED in just a few months.



$+ \ldots \quad \bar{\psi}\psi$



$+ \ldots \quad \bar{\psi}_1 \psi_2 \bar{\psi}_3 \psi_4$

Six-Lepton Z0 Resonance at the Large Hadron Collider

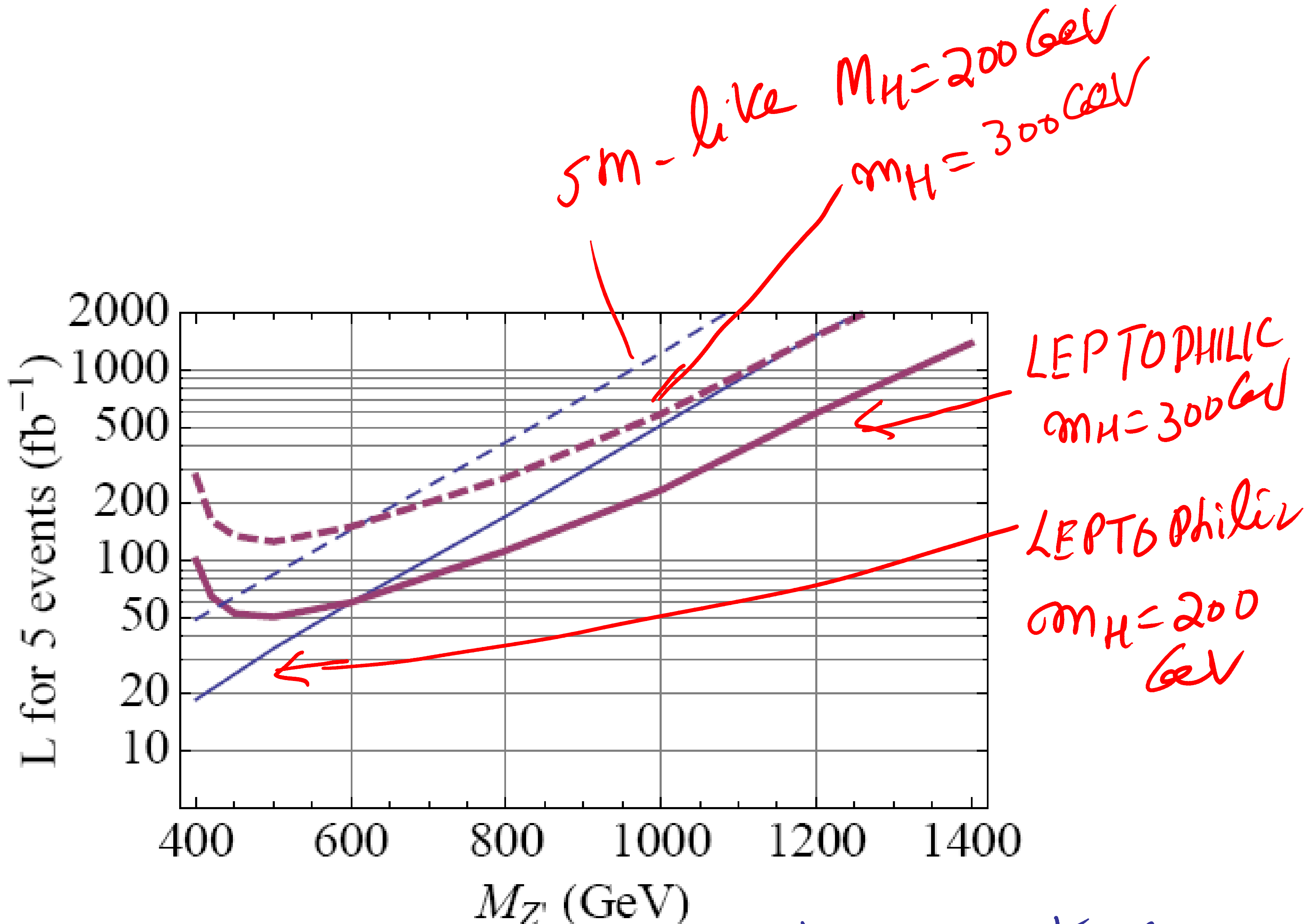
H S Lee [+ Barger + Langacker] PRL '09

New physics models admit the interesting possibility of a Z0 weak boson associated with an extraU(1) gauge symmetry and a Higgs boson that is heavy enough to decay into a pair of Z bosons.Then Z0 production and decay via Z0 ! ZH ! ZZZ has a distinctive LHC signal that is nearlybackground free and reconstructs the H and Z0 masses and widths. The Z0 decay to 3 pairs of leptons is especially distinctive. The ZH decay mode exists even if the Z0 is decoupled from leptons, which motivates an independent 6-lepton resonance search regardless of the dilepton search results.

$Z' \rightarrow Z + H$ → heavy

↳ ZZ

6 Lepton FS: SPECTACULAR!



LUMINOSITY NEEDED for 5 six-lepton events @ LHC ($\sqrt{s} = 14$ TeV)

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CERN-PH-EP/2010-004
March 15, 2010

MODEST BEGINNINGS

Charged-particle multiplicities in pp interactions at $\sqrt{s} = 900$ GeV measured with the ATLAS detector at the LHC

The ATLAS Collaboration

Abstract

The first measurements from proton-proton collisions recorded with the ATLAS detector at the LHC are presented. Data were collected in December 2009 using a minimum-bias trigger during collisions at a centre-of-mass energy of 900 GeV. The charged-particle multiplicity, its dependence on transverse momentum and pseudorapidity, and the relationship between mean transverse momentum and charged-particle multiplicity are measured for events with at least one charged particle in the kinematic range $|\eta| < 2.5$ and $p_T > 500$ MeV. The measurements are compared to Monte Carlo models of proton-proton collisions and to results from other experiments at the same centre-of-mass energy. The charged-particle multiplicity per event and unit of pseudorapidity at $\eta = 0$ is measured to be $1.333 \pm 0.003\,(\text{stat.}) \pm 0.040\,(\text{syst.})$, which is 5–15% higher than the Monte Carlo models predict.

The ATLAS Collaboration

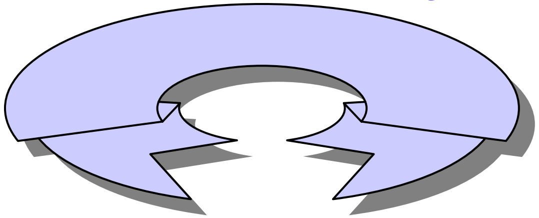
G. Aad[48], E. Abat[18a,*], B. Abbott[110], J. Abdallah[11], A.A. Abdelalim[49], A. Abdesselam[117],
O. Abdinov[10], B. Abi[111], M. Abolins[88], H. Abramowicz[151], H. Abreu[114], E. Acerbi[89a,89b],
B.S. Acharya[162a,162b], M. Ackers[20], D.L. Adams[24], T.N. Addy[56], J. Adelman[173], M. Aderholz[99],
C. Adorisio[36a,36b], P. Adragna[75], T. Adye[128], S. Aefsky[22], J.A. Aguilar-Saavedra[123b],
M. Aharrouche[81], S.P. Ahlen[21], F. Ahles[48], A. Ahmad[146], H. Ahmed[2], M. Ahsan[40], G. Aielli[132a,132b],
T. Akdogan[18a], P.F. Åkesson[29], T.P.A. Åkesson[79], G. Akimoto[153], A.V. Akimov [94], A. Aktas[48],
M.S. Alam[1], M.A. Alam[76], J. Albert[167], S. Albrand[55], M. Aleksa[29], I.N. Aleksandrov[65],
M. Aleppo[89a,89b], F. Alessandria[89a], C. Alexa[25a], G. Alexander[151], G. Alexandre[49], T. Alexopoulos[9],
M. Alhroob[20], M. Aliev[15], G. Alimonti[89a], J. Alison[119], M. Aliyev[10], P.P. Allport[73],
S.E. Allwood-Spiers[53], J. Almond[82], A. Aloisio[102a,102b], R. Alon[169], A. Alonso[79], J. Alonso[14],
M.G. Alviggi[102a,102b], K. Amako[66], P. Amaral[29], G. Ambrosini[16], G. Ambrosio[89a,a], C. Amelung[22],
V.V. Ammosov [127,*], A. Amorim[123a], G. Amorós[165], N. Amram[151], C. Anastopoulos[138], T. Andeen[29],
C.F. Anders[48], K.J. Anderson[30], A. Andreazza[89a,89b], V. Andrei[58a], M-L. Andrieux[55], X.S. Anduaga[70],
A. Angerami[34], F. Anghinolfi[29], N. Anjos[123a], A. Annovi[47,40], A. Antonaki[8], M. Antonelli[47],
S. Antonelli[19a,19b], J. Antos[143b], B. Antunovic[41], F. Anulli[131a], S. Aoun[83], G. Arabidze[8],
I. Aracena[142], Y. Arai[66], A.T.H. Arce[14], J.P. Archambault[28], S. Arfaoui[29,b], J-F. Arguin[14],
T. Argyropoulos[9], E. Arik[18a,*], M. Arik[18a], A.J. Armbruster[87], K.E. Arms[108], S.R. Armstrong[24],
O. Arnaez[4], C. Arnault[114], A. Artamonov[95], D. Arutinov[20], M. Asai[142], S. Asai[153], R. Asfandiyarov[170],
S. Ask[82], B. Åsman[144a,144b], D. Asner[28], L. Asquith[77], K. Assamagan[24], A. Astbury[167],
A. Astvatsatourov[52], B. Athar[1], G. Atoian[173], B. Aubert[4], B. Auerbach[173], E. Auge[114], K. Augsten[126],
M. Aurousseau[4], N. Austin[73], G. Avolio[161], R. Avramidou[9], D. Axen[166], C. Ay[54], G. Azuelos[93,c],
Y. Azuma[153], M.A. Baak[29], G. Baccaglioni[89a], C. Bacci[133a,133b], A.M. Bach[14], H. Bachacou[135],
K. Bachas[29], G. Bachy[29], M. Backes[49], E. Badescu[25a], P. Bagnaia[131a,131b], Y. Bai[32a], D.C. Bailey [156],
T. Bain[156], J.T. Baines[128], O.K. Baker[173], M.D. Baker[24], S Baker[77], F. Baltasar Dos Santos Pedrosa[29],

F. Paige[24]

[24] Brookhaven National Laboratory, Physics Department, Bldg. 510A, Upton, NY 11973, United States of America

i.e. HET

Selected (pheno)research activity



- I) **Tightening the noose**

With Enrico Lunghi (07; 08; 09;10..)

[Many similar past contributions e.g.: with Atwood, Gronau (1997); with London (1997)]

.II) **B-CP anomalies and SM4**

- III) **Desperately seeking b**' (at CDF)

Discussions with Daniel Whiteson, Michael Wilson et al..

- IV) **Composite Higgs @ the LHC**

with Gad Eilam & Shaouly Bar-Shalom

BDK(pi) on the lattice

- With C Aubin(W&M) & D Lin(NCTS, Taiwan)
- Target:

$$r_B \equiv \left[\frac{A(B^+ \to D^0 K^+)}{A(B^+ \to \bar{D}^0 K^+)}\right] \frac{1}{V_{CKM}}$$

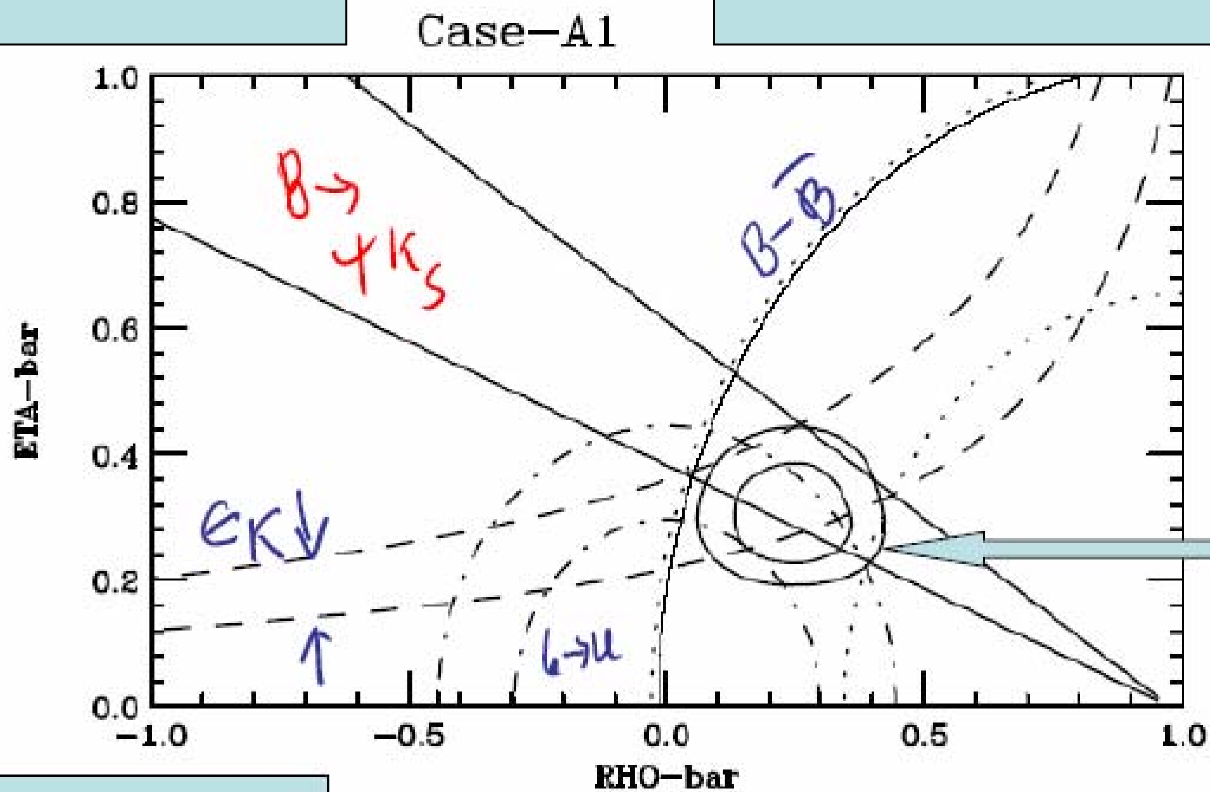
$$\to \frac{1}{N}$$

WOULD HELP γ DETERMINATIONS

1st Hint of confirmation of CKM CP description

Atwood &AS, hepph/0103197

B-CP
ℓ
ISE
Feb~01



NOOSE

Most bands due
To theory errors

New physics will be a perturbation, important to use clean theory and lots of statistics.

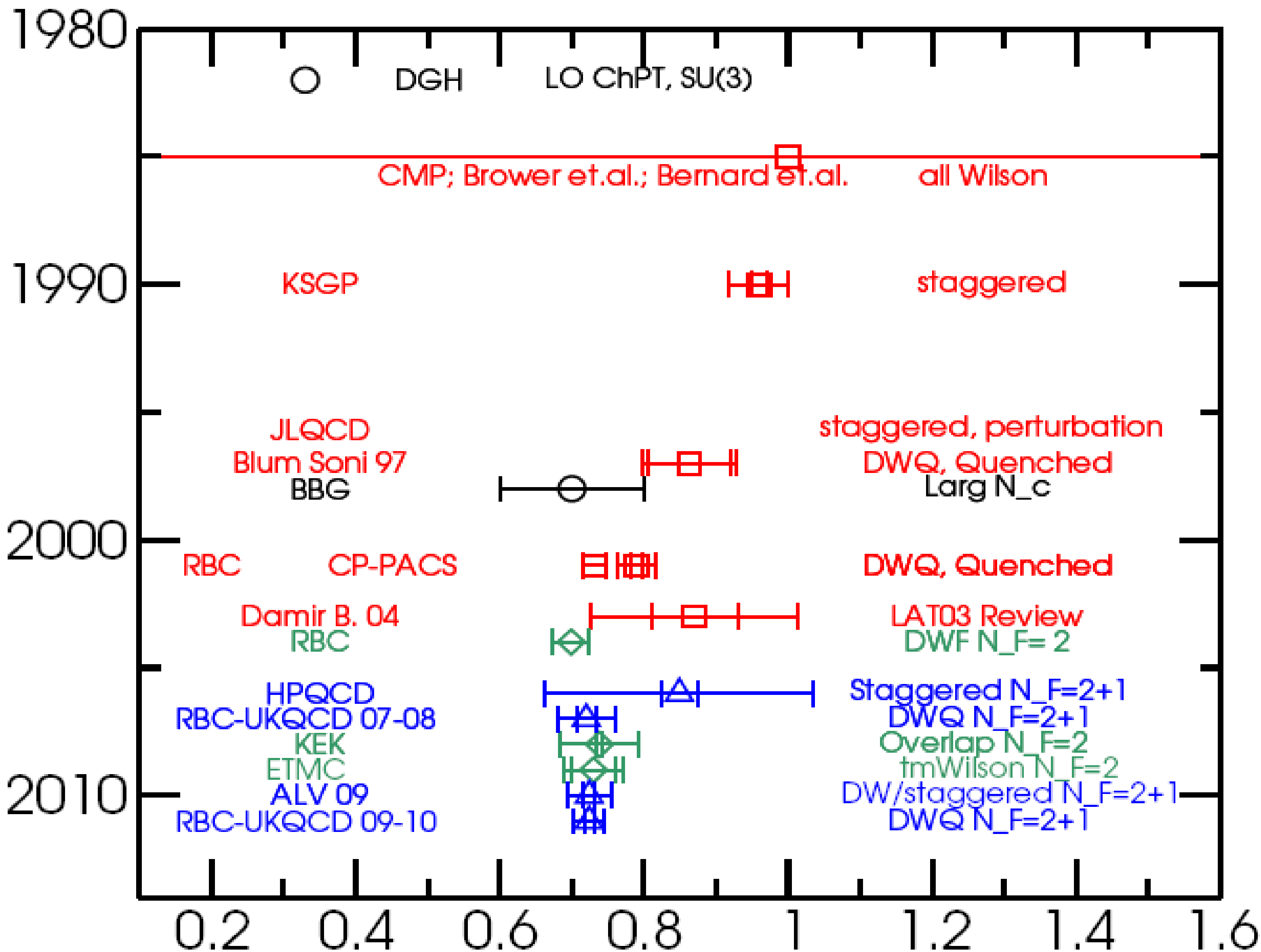


FIG. 20: A brief ($\approx$ 25 years) history of $\hat{B}_K$; from continuum models (black), quenched lattice (red), $N_F = 2$ lattice (green), and $N_F = 2+1$ lattice (blue).

AS @ LAT95

Weak Matrix Elements on the Lattice — Circa 1995

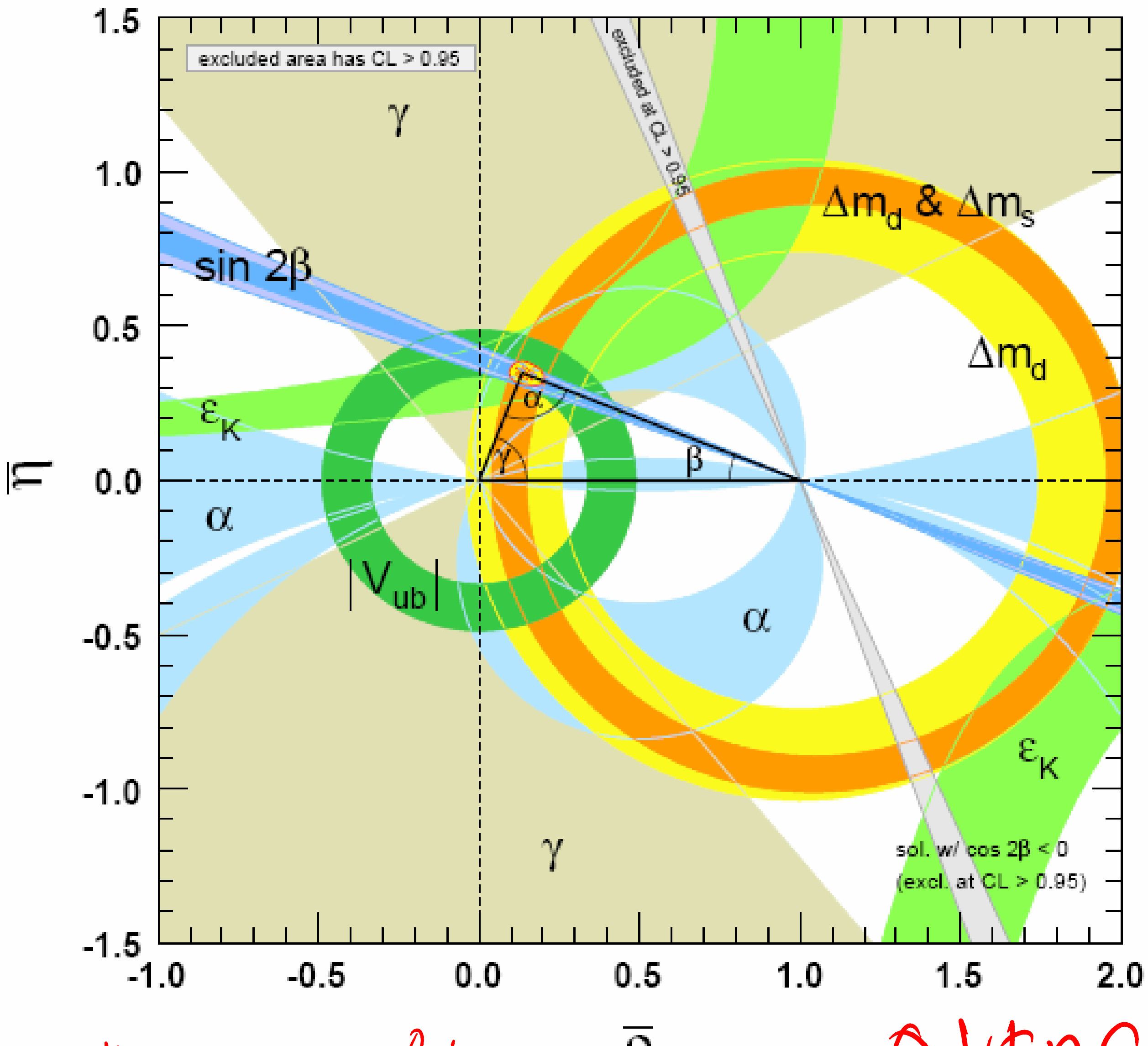
One extremely attractive ("sexy") and rather unique feature of the weak matrix effort on the lattice, that has been recognized for a long time, is that it can have repercussions far beyond QCD.

Courtesy: Tom Browder

Critical Role of the B factories in the verification of the KM hypothesis was recognized and cited by the Nobel Foundation

A single irreducible phase in the weak interaction matrix accounts for most of the CPV observed in kaons and B's.

CP violating effects in the B sector are O(1) rather than O(10^{-3}) as in the kaon system.



Agreement @ ~20% has been way OVERSOLD

2nd

Adapted from Browder

A lesson from history (I)

"A special search at Dubna was carried out by E. Okonov and his group. They did not find a single $K_L \rightarrow \pi^+ \pi^-$ event among 600 decays into charged particles [12] (Anikira et al., JETP 1962). At that stage the search was terminated by the administration of the Lab. The group was unlucky."

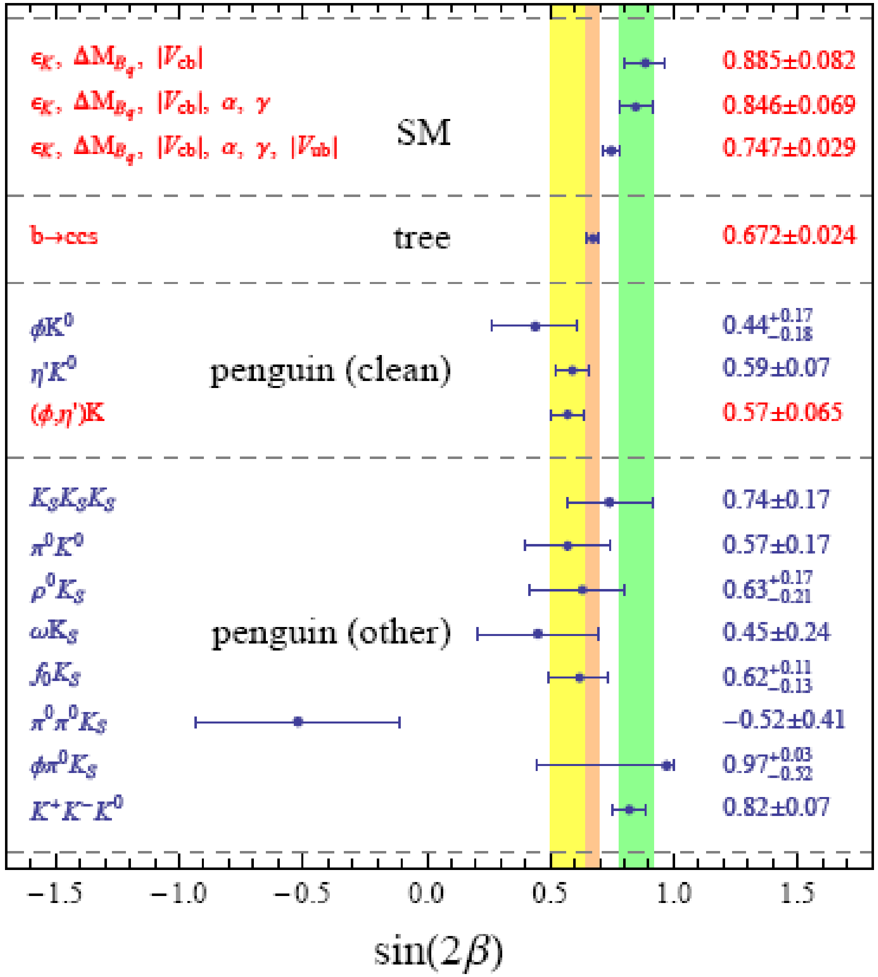
-Lev Okun, "The Vacuum as Seen from Moscow"

1964: BF= 2×10^{-3}

A failure of imagination ? Lack of patience ?

Christenson, Cronin, FITCH + TURLAY BNL '64

Lunghi & AS (arXiv:0903.5059; 0803.4340)



mode	w/out V_{ub}	with V_{ub}
$S_{\psi K_S}$	2.4 σ	2.0 σ
$S_{\phi K_S}$	2.2 σ	1.8 σ
$S_{\eta' K_S}$	2.6 σ	2.1 σ
$S_{(\phi+\eta')K_S}$	2.9 σ	2.5 σ

CKM in peril?

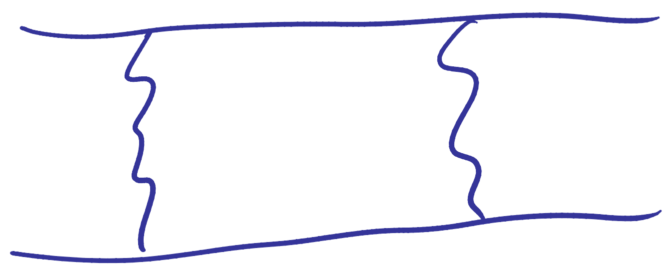
Penguin vs box

A NEW ~~CP~~ phase here

$\Downarrow$

UNNATURAL not to have it here

$\Delta F = 1$

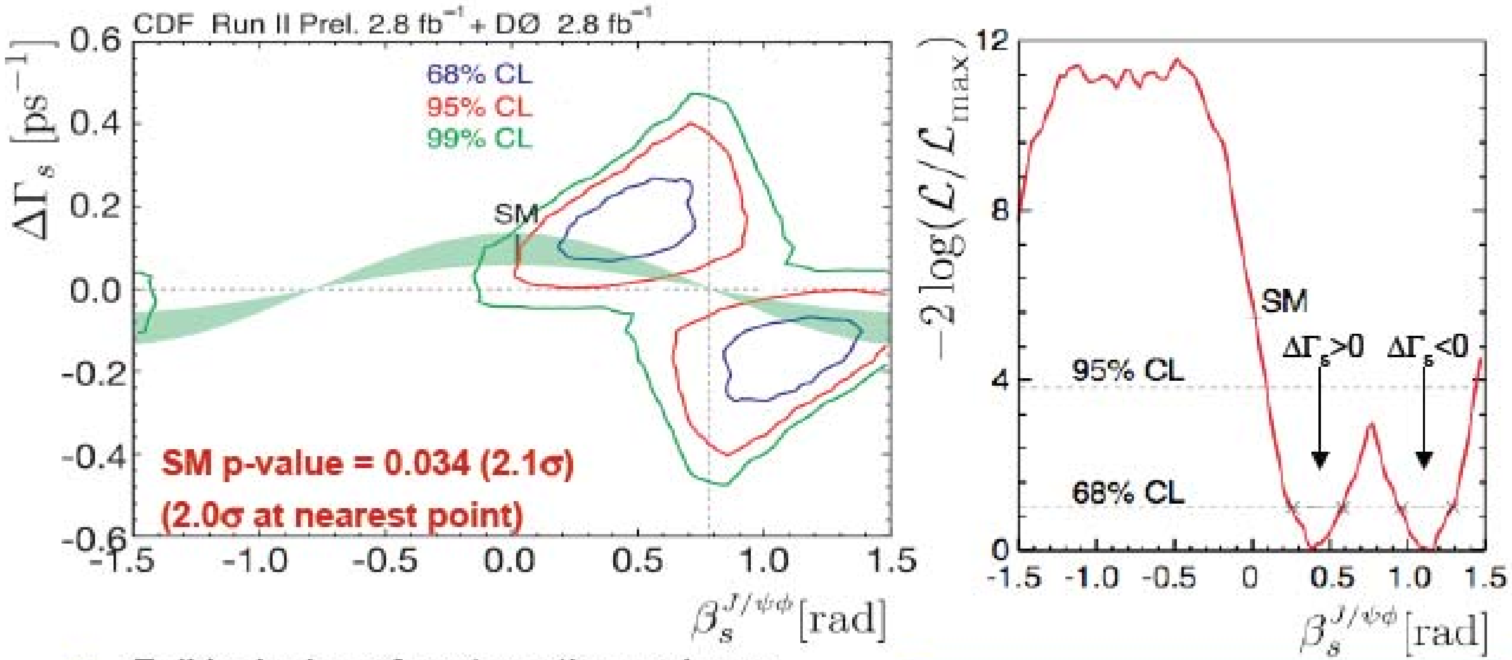


$\Delta F = 2$

PUNZI

Combined Tevatron result

[http://tevbwg.fnal.gov]



- Full inclusion of systematics and non-Gaussian effects. No external constraints.
- Compared to HFAG 2008:
  Larger CDF sample + Better accounting for tails ⇒ same level of SM agreement.

$\beta_s^{J/\psi\phi}$ range:
[0.27,0.59] U [0.97,1.30] @68%
[0.10,1.42] @95%
1-D p-value for SM= 0.020 (2.3σ)

Evidence for an anomalous like-sign dimuon charge asymmetry

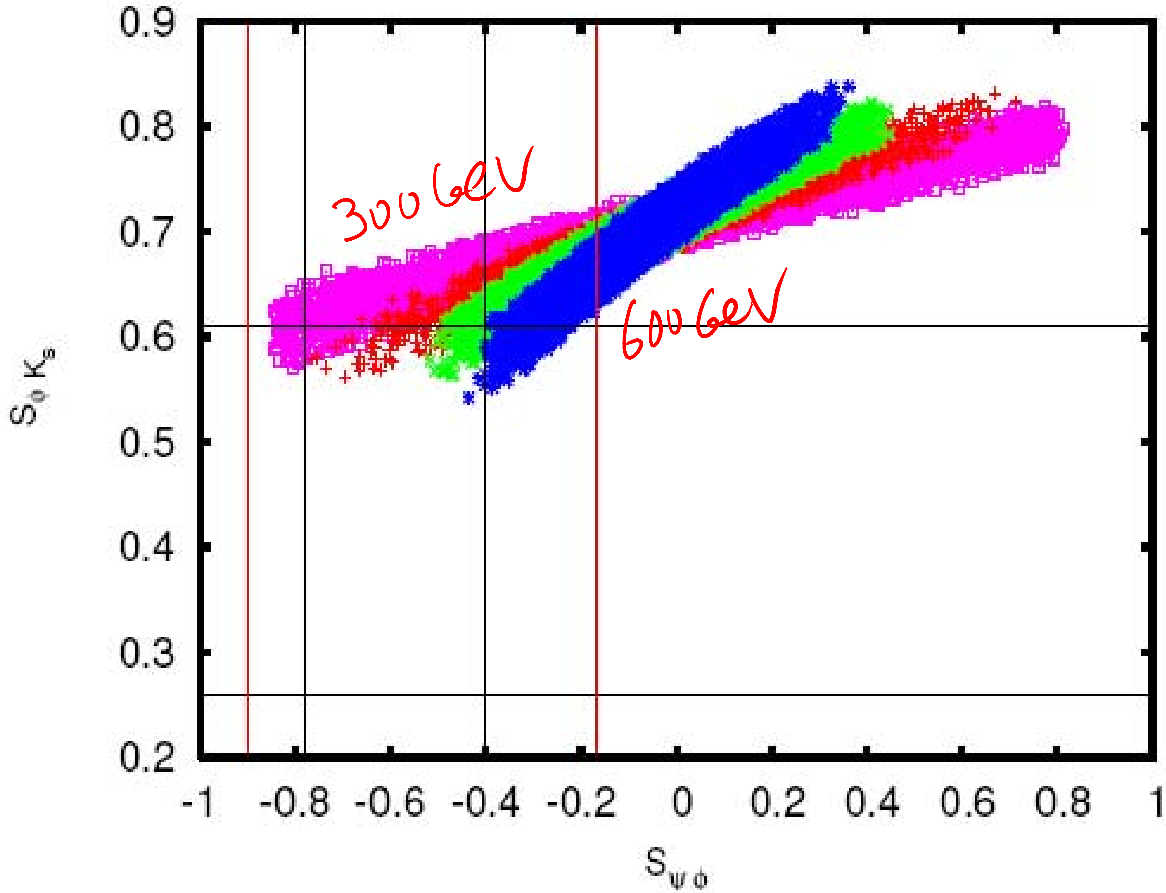
We measure the charge asymmetry A of like-sign dimuon events in 6.1 fb^{-1} of $p\bar{p}$ collisions recorded with the D0 detector at a center-of-mass energy $\sqrt{s} = 1.96$ TeV at the Fermilab Tevatron collider. From A, we extract the like-sign dimuon charge asymmetry in semileptonic b-hadron decays: $A^b_{\rm sl} = -0.00957 \pm 0.00251\,(\text{stat}) \pm 0.00146\,(\text{syst})$. This result differs by 3.2 standard deviations from the standard model prediction $A^b_{\rm sl}(SM) = (-2.3^{+0.5}_{-0.6}) \times 10^{-4}$ and provides first evidence of anomalous CP-violation in the mixing of neutral B mesons.

NYTIMES 5/18/10

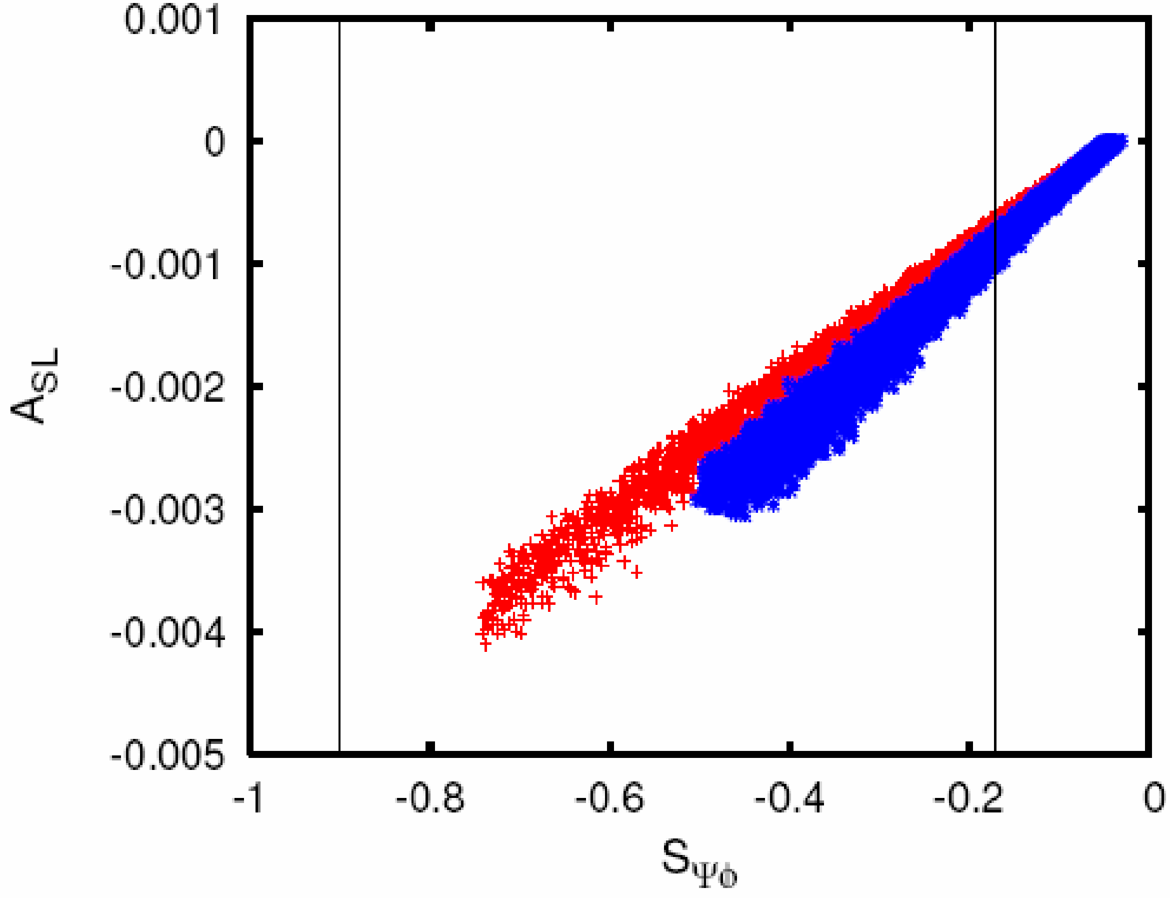
POSTED 5/17/10

Fermilab Seminar 5/14/10

4th Generation signals?



See arXiv:0807.1971; 1002.0595



0.001
0
-0.001
-0.002
-0.003
-0.004
-0.005
-1
-0.8
-0.6
-0.4
-0.2
0
A_{SL}
$S_{\Psi\phi}$

The "3-prong composite solution" to the SM4

(figure taken from: Chanowitz, Phys.Rev.D79:113008,2009)

BAR-SHALOM,EILAM+AS, arXiv:1001.0569

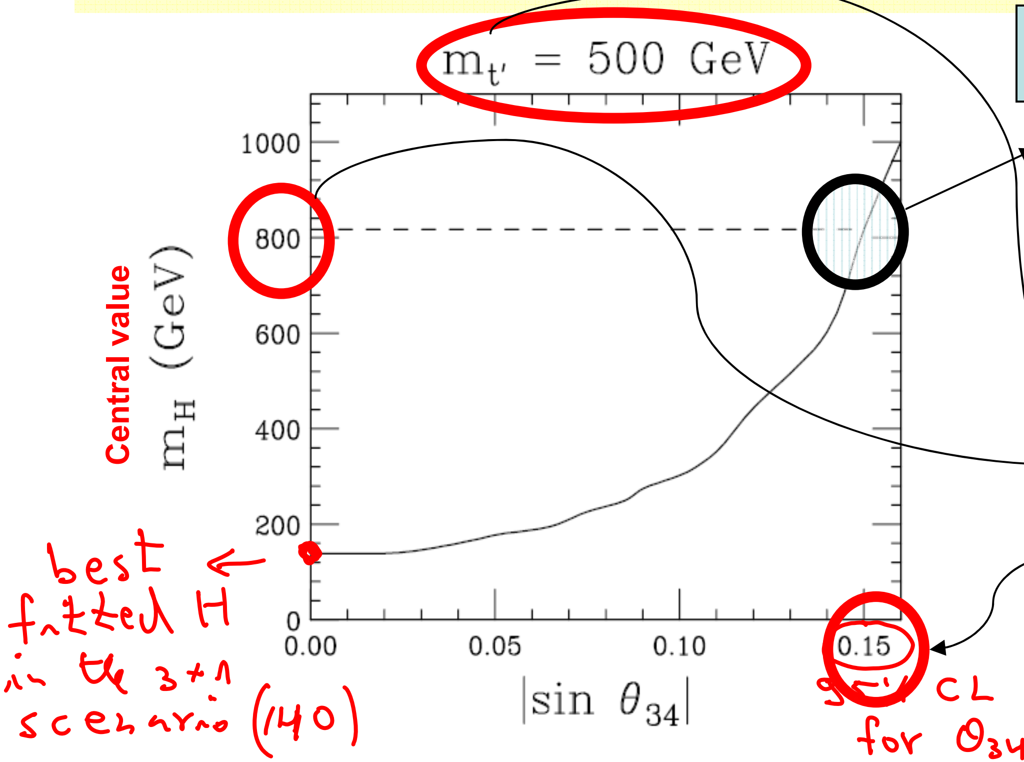


Figure 2: Higgs boson mass as a function of $|\sin\theta_{34}|$ for the global fit to the four family with $m_{t'} = 500$ GeV. The horizontal line indicates the 95% confidence interval for |si

$$m_{t'} - m_{b'} \approx \left(1 + \frac{\ln \frac{m_H}{115\ \mathrm{GeV}}}{5}\right) \times 50\ \mathrm{GeV}$$

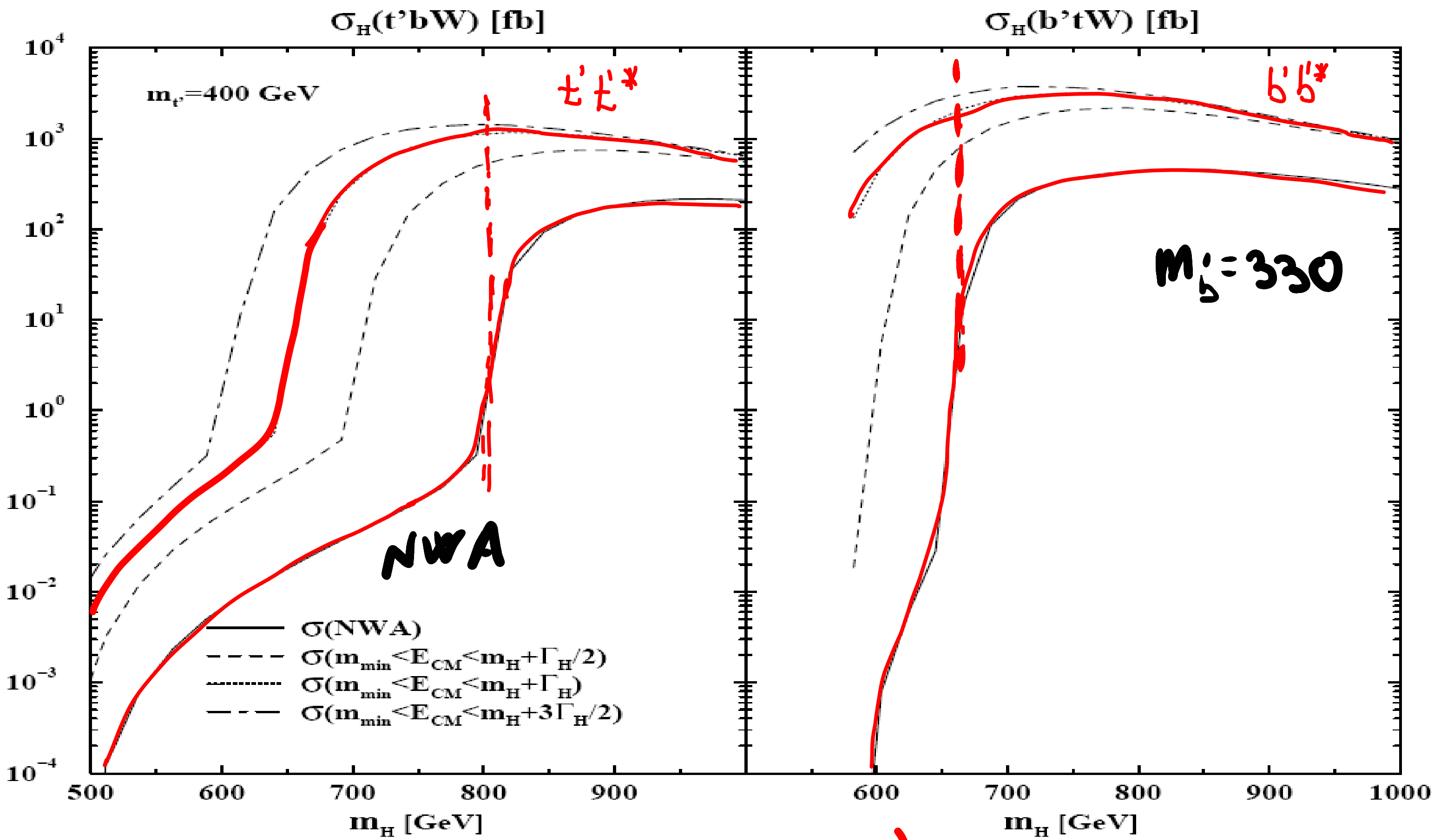
The compositeness SM4 "spot"?

$m_H \sim O(1)$ TeV $< 2m_{t'b'}$

$\theta_{34} \sim O(0.1)$ —— $m_{t',b'} \sim O(500)$ GeV

Further hints from:

- compositeness
- Flavor data
- Direct searches



e.g. $\sigma_H(pp\to H\to t'bW) \sim 300\ fb$

at $m_H \sim 700$ GeV

$m_{t'} \sim 400$ GeV

(where $\sigma_H(NWA) \sim 0.03\ fb$)

EILAM,BAR-SHALOM+AS

PARTING REMARKS: Group Issues

Noteable Features of HET

I. HET group is involved in diverse areas of HEP, precision EW, flavor, collider & LHC phenomenology and has a strong lattice gauge effort.

II. Group has strong publication record (list of recent pubs attached).

III. Several members have made groundbreaking contributions; many have won notable awards and many are serving on important committees.

IV. The group is extremely tightly coupled to important experimental programs, it has a long history of initiating important new projects and its work is superbly aligned with the DOE's mission and priorities

Features recognized by '08 DOE REVIEW

Summary of the comments of the panel of reviewers

- **Many panelists thought that lab theory groups should clearly identify unique missions and contributions that can serve to distinguish them from university groups.**
- **Panel members generally had a favorable opinion of BNL-HET in this sense as they felt that it has “distinguished itself in this regard by providing strong support to the experimental program at BNL and in shaping DOE HEP programs”**

With regard to the lattice activities

- **The panel was quite surprised that in effect there was only 0.5 FTE actually involved in large scale lattice QCD simulations**
- **Recent appointments of Taku Izubuchi and Ruth Van De Water were seen as a positive development in this regard**

Summary on the HET Group

The effort of the HET Group at BNL is shaped by the unique strengths and special responsibilities of a National Laboratory theory group.

- ✓ **Accomplishments of high scientific significance and impact**
- ✓ **Well aligned with HEP National strategic plans and priorities**
- ✓ **A central role in BNL's core experimental programs & well aligned with the DOE's plan and mission**
- ✓ **Closely coupled to Lab resources**
- ✓ **Strong leadership roles in the scientific community**
- ✓ **A strong role in the education and training of future scientists**

Some Concerns

- We try extremely hard to be as cost effective as possible
- Huge Leverage: Goldhaber Fellowship, PECASE, DIVERSITY support…
- MORE LEVERAGE: LATTICE: Columbia, RBRC, RIKEN (JAPAN)…
- Significant increase in computing hardware; hardware is essential but so are people if the hardware is to be used effectively
- Extremely concerned about post-doc reduction esp. also as the LHC is in full swing(also loosing a student)

- **Need regular student support & support for modest summer program**
- **SHOULD NOTE: Students & Post-docs tend to do rather well after BNL-HET: (last year Sholze, Gopalakrishna, Jack Laiho , 3 moved to tenure track jobs)**
- **This year Almeida->Saclay; Kile-> Northwesten; Sturm->Munich**
- **Tightness of budget makes it extremely difficult to have even a modest summer program, support for students or meet very limited sabbatical request(s) (e.g. Wai Yee Keung [former PD])**

BOTTOM LINE

- **Budget shortfall, if not remedied, can have very serious consequences for the health and the vitality of the group…**

We believe we deserve more support and (alas!) we do desperately need more!

Group publications: Jan ‘09 – May ‘10

<u>High Energy Theory Group Publications</u>

January 2009 - May 2010

M. Creutz, *Anomalies and discrete chiral symmetries*, arXiv:0909.5101 [hep-ph], 2009.

M. Creutz, *Anomalies and chiral symmetry in QCD*, Annals Phys.324:1573-1584; arXiv:0901.0150 [hep-ph], 2009.

H. Davoudiasl, et al., *The Hunt for New Physics at the Large Hadron Collider;* arXiv:1001.2693 [hep-ph], 2010.

H. Davoudiasl, G. Perez, (Weizmann Inst.) *The INTEGRAL/SPI 511 keV Signal from Hidden Valleys in Type Ia and Core Collapse Supernova Explosion*, JHEP 1004:058, arXiv:0912.3320 [hep-ph], 2010.

H. Davoudiasl, *Echoes from a Warped Dimension*, Published in Nucl.Phys.Proc.Suppl., 200-202:149-158, arXiv:0909.1587 [hep-ph], 2010.

H. Davoudiasl, P. Huber, *Thermal production of axions in the Earth,* arXiv:0903.0618 [hep-ph], 2009.

H. Davoudiasl, *Signals of Warped Top-Condensation in B-Decays,* AIP Conf. Proc.1200:631-634; arXiv:0909.3542 [hep-ph], 2009.

T. Izubuchi, et al., *Improving chiral property of domain-wall fermions by reweighting method,* RBRC-778, Mar 2010, PoS LAT2009:035;arXiv:1003.2182 [hep-lat], 2009.

T. Izubuchi, *Studies of the QCD and QED effects on isospin breaking*, By RBC and UKQCD Collaborations, PoS KAON09:034, 2009.

T. Izubuchi, A. Soni, C. Sturm, Y. Aoki, N.H. Christ, C.T.C. Sachrajda, *Renormalization of quark bilinear operators in a MOM-scheme with a non-exceptional subtraction point,* arXive:0901.2599*,* 2009.

J. Kile, *Light Fermionic Dark Matter and its Possible Detection in Neutrino Experiments,* AIP Conf.Proc.1200:1035-1038, arXiv: 0910.5051 [hep-ph], 2009.

J. Kile, A. Soni, *Hidden MeV-Scale Dark Matter in Neutrino Detectors*,
arXiv: 0908.3892 [hep-ph], 2009.

H-S Lee, et al., *Bound on Z' Mass from CDMS II in the Dark Left-Right Gauge Model II*; Phys.Rev.D81:051702; arXiv:1002.0692 [hep-ph], 2010.

H-S Lee, et al., *Gauged B-x_i L origin of R parity and its implications*. UCRHEP-T483. Phys.Lett.B688:319-322,2010; arXiv:1001.0768 [hep-ph], 2010.

H-S Lee, et al., *New physics search at the LHC via Z-prime resonance,*
UCRHEP-T475, 2009; AIP Conf.Proc.1200:786-789

T. McElmurry, et al., *QCD Corrections to Scalar Diquark Production at Hadron Colliders,* JHEP 1001; arXiv:0909.2666 [hep-ph], 2010.

F. Paige, *The ATLAS Inner Detector commissioning and calibration,* arXiv:1004.5293 [physics.ins-det], 2010.

F. Paige, *Charged-particle multiplicities in pp interactions at sqrt(s) = 900 GeV measured with the ATLAS detector at the LHC,* arXiv:1003.3124 [hep-ex], 2010.

F. Paige*, Expected Performance of the ATLAS Experiment - Detector, Trigger and Physics,* arXiv:0901.0512 [hep-ex], 2009.

A. Soni, et al., *SM with four generations: Selected implications for rare B and K decays*; arXiv:1002.0595 [hep-ph], 2010.

A. Soni, et al., *Neutral B-meson mixing from unquenched lattice QCD with domain-wall light quarks and static b-quarks*; CU-TP-1192, EDINBURGH-2010-1, RBRC-827, SHEP-0928 ;arXiv:1001.2023 [hep-lat], 2010.

A. Soni, et al., *Collider signals of a composite Higgs in the Standard Model with four generations*; Published in Phys.Lett.B688:195-201; arXiv:1001.0569 [hep-ph], 2010.

A. Soni, et al., *Big Signals of Little Randall-Sundrum Models*. Published in Phys.Lett.B686:239-243,2010, arXiv:0908.1131 [hep-ph], 2010.

A. Soni *et al., Flavor Physics in the Quark Sector*, arXiv:0907.5386 [hep-ph], 2009.

A. Soni, *The '4th generation', B-CP anomalies & the LHC,* arXiv:0907.2057 [hep-ph], 2009.

A. Soni, E. Lunghi, *Hints for the scale of new CP-violating physics from B-CP anomalies*, arXiv:0903.5059 [hep-ph]; JHEP 0908:051, 2009.

C. Sturm, L. Almeida, *Two-loop matching factors for light quark masses and three-loop mass anomalous dimensions in the RI/SMOM schemes*; arXiv:1004.4613 [hep-ph], 2010.

C. Sturm, S. Uccirati, *Higgs Pseudo-Observables, Second Riemann Sheet and All That,* TTP-10-04; Nucl.Phys.B834:77-115; arXiv:1001.3360 [hep-ph], 2010.

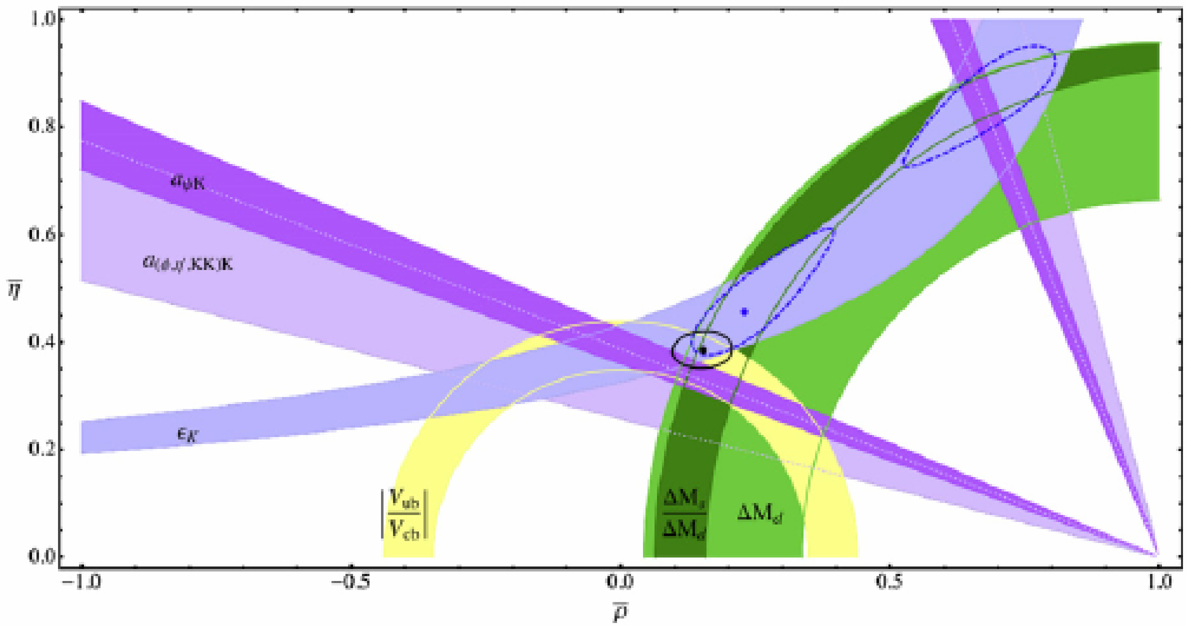
R. Van de Water, *The CKM matrix and flavor physics from lattice QCD*, arXiv:0911.3127 [hep-lat], 2009.

R. Van de Water *et al.*, *Lattice QCD inputs to the CKM unitarity triangle analysis*; HET-535, Phys.Rev.D81:034503; arXiv:0910.2928 [hep-ph], 2010.

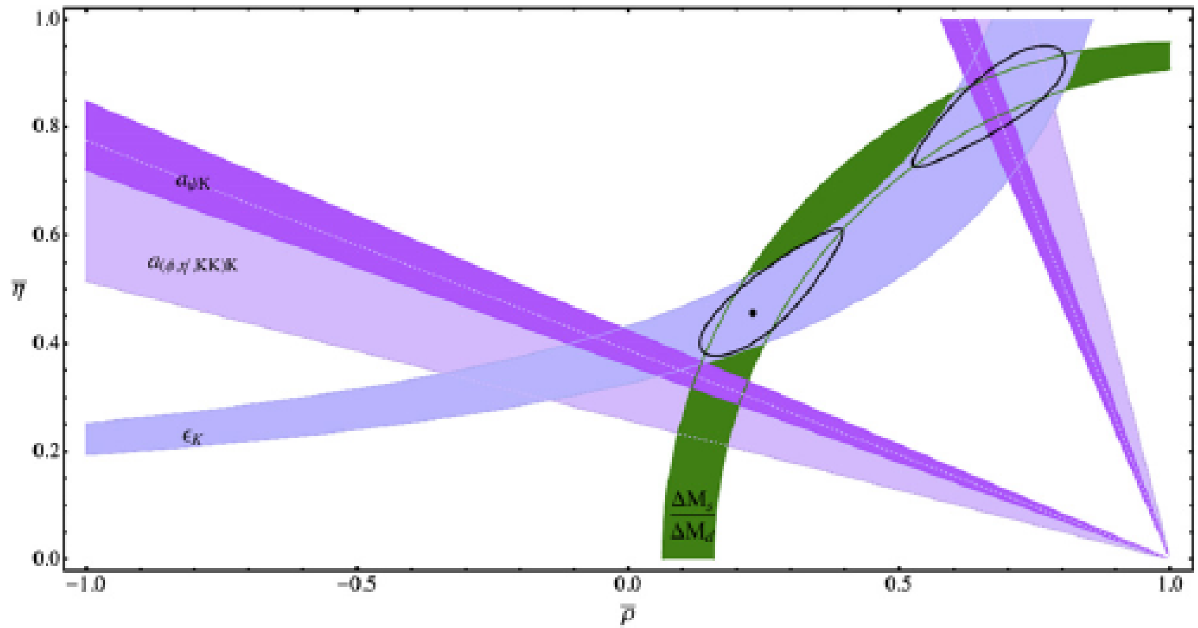
R. Van de Water *et al.*, *Visualization of semileptonic form factors from lattice QCD,* arXiv:0906.2498 [hep-lat]; Phys.Rev.D80:034026, 2009.

R. Van de Water, C. Aubin, J. Laiho, *The neutral kaon mixing parameter B_K from unquenched mixed-action lattice QCD,* arXiv:0905.3947 [hep-lat], 2009.

BACKUPS



$a_{\psi K}$
$a_{(\phi,\eta',KK)K}$
ϵ_K
$\left|\frac{V_{ub}}{V_{cb}}\right|$
$\frac{\Delta M_s}{\Delta M_d}$
ΔM_d
$\bar{\eta}$
$\bar{\rho}$



1.0
0.8
0.6
0.4
0.2
0.0
$\bar{\eta}$
$a_{\psi K}$
$a_{(\phi,\eta')K K K}$
ϵ_K
$\frac{\Delta M_s}{\Delta M_d}$
−1.0
−0.5
0.0
0.5
1.0
$\bar{\rho}$

ENTIRELY NEW APPROACH: UT WITHOUT SEMI-LEPTONIC DECAYS

Lunghi+ AS, 0912.0002

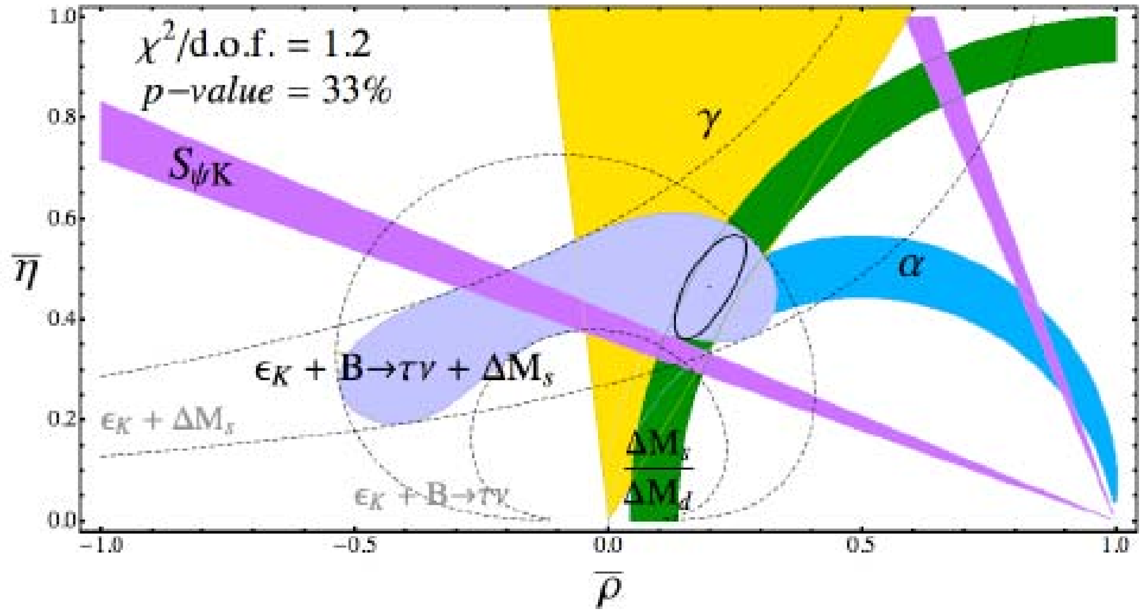
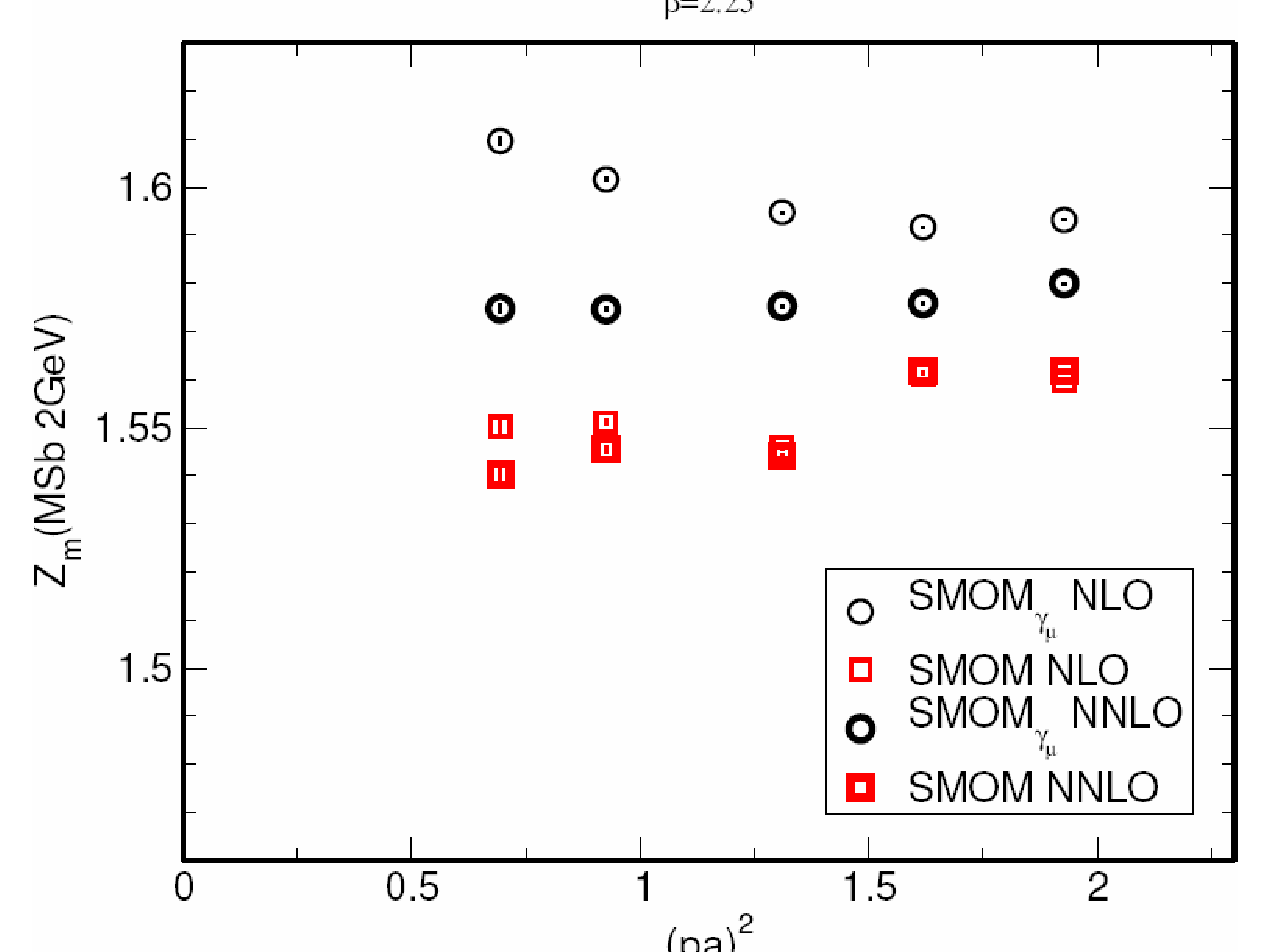


FIG. 2: Unitarity triangle fit without semileptonic decays. The solid contour is obtained using ε_K, $B \to \tau\nu$, γ, ΔM_{B_s} and ΔM_{B_d}. The dashed contours show the interplay of the ε_K, ΔM_{B_s} and BR($B \to \tau\nu$) constraints.

$\boxed{\sin 2\beta \sim 1.86}$

NEED IMPROVED BR $B \to \tau\nu$
($\not{f}_B$)



β=2.25
1.6
1.55
1.5
0
0.5
1
1.5
2
Z_m(MSb 2GeV)
$(pa)^2$
SMOM$_{\gamma_\mu}$ NLO
SMOM NLO
SMOM$_{\gamma_\mu}$ NNLO
SMOM NNLO

Lunghi & AS, arXiv: 0903:5059

Scenario	Operator	Λ (TeV)	φ ($^\circ$)
B_d mixing	$O_1^{(d)}$	$\begin{cases} 1.1 \div 2.1 & \text{no } V_{ub} \\ 1.4 \div 2.3 & \text{with } V_{ub} \end{cases}$	$\begin{cases} 15 \div 92 & \text{no } V_{ub} \\ 6 \div 60 & \text{with } V_{ub} \end{cases}$
$B_d = B_s$ mixing	$O_1^{(d)}$ & $O_1^{(s)}$	$\begin{cases} 1.0 \div 1.4 & \text{no } V_{ub} \\ 1.1 \div 2.0 & \text{with } V_{ub} \end{cases}$	$\begin{cases} 25 \div 73 & \text{no } V_{ub} \\ 9 \div 60 & \text{with } V_{ub} \end{cases}$
K mixing	$O_1^{(K)}$ $O_4^{(K)}$	< 1.9 < 24	$130 \div 320$
$\mathcal{A}_{b\to s}$	$O_4^{b\to s}$ $O_{3Q}^{b\to s}$	$.25 \div .43$ $.09 \div .2$	$0 \div 70$ $0 \div 30$

Table 2. Bounds on the scale and phase of NP contributions to B_d, B_s, K mixing and to $b \to s\bar{s}s$ penguin amplitudes. Λ and φ are defined in eqs. (4.7) and (5.4).

GREAT NEWS FOR THE LHC!